Interdisciplinary Research Programs in Geophysical Fluid Dynamics

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LONG-TERM GOALS

The long-term goals are to train new scientists to conduct research, and to enhance the abilities of experienced research workers in geophysical fluid dynamics. This field is fundamental to the field of numerical forecasting of ocean, atmosphere and environment.

OBJECTIVES

To help graduate students formulate and tackle innovative research problems in GFD. To promote an exchange of knowledge and ideas between investigators in the different scientific disciplines that deal with the dynamics of stratified fluids, rotating fluids, fluid with phase changes and non-Newtonian fluids. To formulate tractable, important problems which are presently at the fringe of our understanding in the field of Geophysical Fluid Dynamics. To serve as a clearing-house for the mathematical, experimental and computational techniques which serve astrophysics, climate science, geodynamics, meteorology and oceanography.

APPROACH

We conduct a summer study school of ten weeks duration each summer. The participants are graduate student Fellows, visiting graduate students and visiting scientists. The first two weeks consist of ten principal lectures in the summer's topic conducted by an expert in that area. Lectures by associated participants follow at a rate of roughly one or two per day for the remaining weeks except for the last

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week, when student Fellows present their results. About 10 graduate students are admitted as Fellows, selected from a pool of applicants from many disciplines who are in their second to forth year of graduate school. Fellows receive a stipend for the full ten weeks. A Fellow conducts a research project under the guidance of the staff, provides a written project report, and orally present results in the tenth week. The Fellows also prepare note of the principal lectures. Several other graduate students visit for shorter periods to listen to lectures and interact with the staff. The staff and faculty (comprised of all of the visiting scientists) are continually renewed throughout the summer, although there is a core faculty who remain for the entire summer. Most of these participants receive partial travel support from the program, but some participate for free. The lecture notes and the written report of the Fellows' projects are contained in a volume that is distributed in print form and is available on the GFD website.

TASKS COMPLETED

The subject of this year's principal lectures was Boundary layers. The Principal Lecturer was Joseph Pedlosky of Woods Hole Oceanographic Institution with one lecture by Steven Lentz. Research to develop understanding and Representating boundary layers is an area of active development for many reasons. Boundary layers are not completely resolved in numerical models of the ocean. The bottom mixed layer in an ocean coastal region determines the rate of local upwelling, front positions, sediment transport (hence bottom characteristics) and turbidity. The top boundary layer influences air-sea flux, acoustic scattering, sound propagation, and visibility of both air and water. Regions requiring development of accurate formulas to express boundary layer effects include continental shelves, coastal regions, estuaries, narrow channels, river mouths and in gaps between islands

The year 2007 had the subject of “Boundary Layers”. Fellows names, main interests, university affiliations and titles of their projects were:

- Rebecca Dell, Physical Oceanography, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution Joint Program, “Nonlinear modifications to the Ekman Layer by an advecting geostrophic flow”.
- Basile Gallet, Physics, Ecole Normale Superieure, “Instability theory of swirling flows with suction”.
- Jeroen Hazewinkel, Applied Mathematics/Oceanography, Royal Netherlands Institute for Sea Research, Amsterdam University, “Internal wave radiation by gravity currents down a slope”.
- Miranda Holmes, Applied Mathematics and Atmosphere Ocean Science, Courant Institute of Mathematical Science, New York University, “Length and shape of a lava tube”.
- Iva Kavcic, Meteorology, Department of Geophysics, University of Zagreb, Croatia, “Circular internal hydraulic jump”.
- Frederic Laliberte, Mathematics and Applied Ocean Science, New York University, “Double diffusive effects in a dam break experiment”.
- Angel Ruiz-Angulo, Mechanical Engineering, Caltech, “Differential diffusion paradox for turbulent flow”.

- Henrik van Lengerich, Chemical Engineering, Cornell University, “Convection of a van der Waals fluid near the critical point”.
- Andrew Wells, Applied Mathematics, University of Cambridge, “Skinny dipping in Woods Hole: investigating near surface variations in sea temperature”.
- Jan Zika, Physical Oceanography, University of New South Wales, “The stability of cascading flows”.

RESULTS

The Principal Lectures and Fellows' reports are the tangible results. They are available as a technical report and on the web. A number of published papers typically result from the program, many are listed on the web page.

IMPACT FOR SCIENCE

Many staff, fellows and visitors express their enthusiasm at the end of each summer. We conducted a survey 5 years ago for the past 20 years of Fellows as part of the celebration of the 40th year of the program. About 80% of the remarks were highly complimentary. A few of the roughly 50 responses are given here:

“The GFD program is a great educational experience which introduces many talented future scientists to our field. We should make every effort to make sure it continues for many generations of new scientists. Adding more visiting lecturers can be beneficial to all.”

“The GFD faculty was, taken as a group, as good as or better than the best department anywhere. It was a real treat to be a student/Fellow of this group.”

“The most valuable lesson for me was watching this accomplished group 'do science'. I learned more from interacting with them, and watching/listening to them interact with one another and with other Fellows than from any specific problem or piece of research.”

Some Fellows had serious suggestions for improvement, such as:

“I chose the wrong project with the wrong advisor. I didn’t get much out of the summer. But, in a different situation, I definitely would have.”

Because of the last remark, the staff increasingly pays attention to each fellow and works to make each fellow achieve a good project in conjunction with a suitable advisor. The Dean’s office also has the Fellows evaluate the program, and many comments are similar to those given here.

RELATIONSHIPS TO OTHER PROGRAMS

We estimate that typically 20-50% of the student projects become included in their thesis or postdoctoral work and/or result in publications. The program does not follow the Fellows' research after the summer is finished although individual staff members often remain involved with the Fellows'

continuation of their projects past the end of the summer. All staff members are active research workers, so numerous related projects exist.

FIGURES/PICTURES

Figure 1. On the left, Joseph Pedlosky during the principal lecture Walsh Cottage. In the middle is Steven Lentz showing observations of boundary layers in the ocean surface and bottom, and on the right the attendees.

REFERENCES

Various features of the program are listed on website http://www.whoi.edu/page.do?pid=7937. This includes a list of past Fellows, the titles of the lectures, a list of participating scientists, a yearly newsletter, and recent past volumes (containing lecture notes and the fellows' project reports).

PUBLICATIONS

Lecture notes and fellows reports are listed in the above website.

HONORS

J. A. Whitehead of Woods Hole Oceanographic Institution received the Henry M. Stommel Research Award from the Americal Meteorological Society in 2007.